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Real-time Kinematics Base Station and Survey Unit Setup Method for the Synchronous Impulse Reconstruction (SIRE) Radar

by Francois Koenig and Getachew Kirose

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14. ABSTRACT

This report provides a description of the real-time kinematics (RTK) global positioning system (GPS) operation and setup procedure to provide real-time survey data for the Synchronous Impulse Reconstruction (SIRE) radar. These accurate position data allow proper real-time registration of surveyed points of interest with the SIRE radar imagery.

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SIRE radar, real time kinematic global positioning system, differential global positioning system

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1. Background

Field experiments involving the U.S. Army Research Laboratory's (ARL) Synchronous Impulse Reconstruction (SIRE) radar (*1*) require collection of accurate position data not only for the vehicle's location but also for the targets. These accurate position data allow proper real-time registration of surveyed points of interest with the SIRE radar imagery. As a result, we have implemented a real-time kinematic (RTK) global positioning system (GPS) survey procedure to locate points of interest with centimeter accuracy. Previously, we have discussed the advantages of the RTK method of Differential GPS (DGPS) operation using a local base station and a rover with an onsite radio frequency (RF) telemetry link (*2*). This report extends that concept using new GPS equipment, RF modems and a survey unit.

Section 1 provides background information on DGPS and the application of RTK operation. Section 2 describes the step-by-step recommended operating procedure for RTK base station setup and operation. Section 3 describes the RTK survey unit setup and operation using Ashtech's FAST Survey program.

1.1 Initial Transceiver Configuration

Our RF telemetry link consists of two 3.4-GHz radio modems, FreeWave 3400-SMR. The 3400-SMR transceivers need to be programmed initially for their designated mode of operation. This configuration only needs to be done once since it is stored in nonvolatile memory in the device. We used FreeWave's provided utility to configure the base 3400-SMR as a transmitter/server in a point-to-multipoint network. The survey 3400-SMR was configured as a receiver/client. Under such a network, the base will send out corrections, repeated three times to insure error-free reception, but not expect an acknowledgement from the survey unit.

1.2 Obtain an Accurate Base Station Location

Before we can begin to transmit accurate position data from the base station, we need to know exactly where it is located. The simplest way of obtaining the location coordinates is to locate the base station at a previously surveyed position. In this case, the GPS antenna would be placed exactly over the survey point and its previously determined GPS coordinates would be used.

Unfortunately, survey points are not always available near a desirable base station location, especially for this RTK method, which requires line of sight between the base and rover. If a prior survey has not been performed, we need to record base station position data for several hours or more and post-process the data against a known base station. Continuously operated reference stations (CORS) are listed at http://www.ngs.noaa.gov/CORS/ and their GPS RINEX2 data can be downloaded for our recorded time period. We then perform the post-processing technique described in reference 3, where the nearest CORS station is treated as the known

"base" and our base station becomes the "rover." The centroid of the post-processed "rover" location coordinates becomes the GPS coordinate used in the RTK base station entry.

2. Base Station

The base station consists of a GPS receiver, the Novatel DL-V3; a 3.4-GHz radio modem, the FreeWave 3400-SMR; a choke ring GPS antenna; a 12-V battery pack, and tripods to support the GPS antenna and radio antenna. The interconnect diagram is shown in figure 1 followed by photos of the radio and GPS receiver in figure 2. Interconnecting cables are identified in table 1.
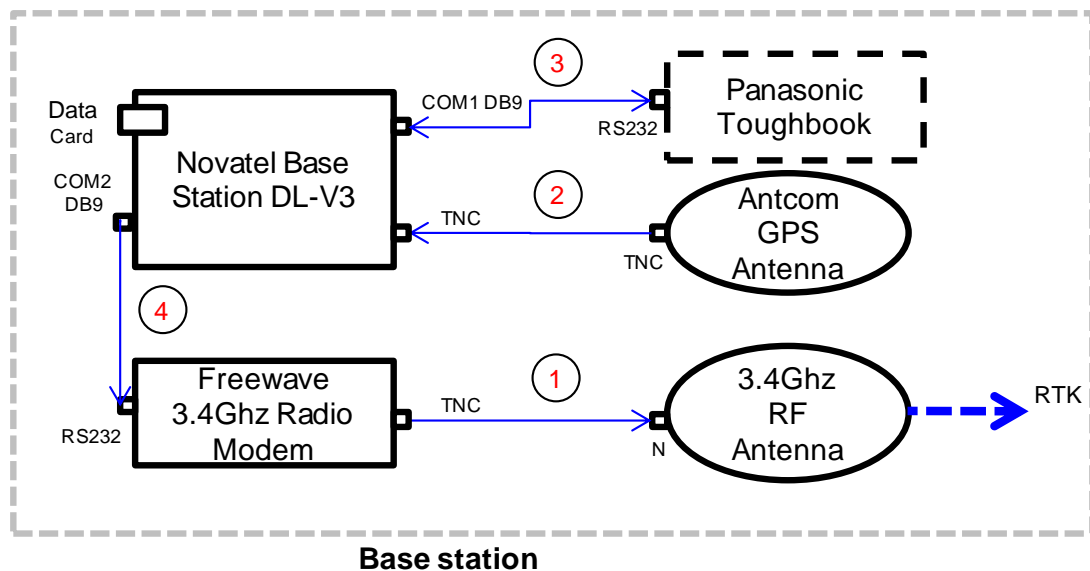

Figure 1. Base station interconnect diagram.

Figure 2. Photos of the radio and GPS receiver.

Table 1. Interconnecting cables for base station and survey unit.

Item	Cable	Connection
1	type N to TNC 10-ft coax (LMR-240)	radio ant to radio
2	TNC to TNC 10-ft coax (RG-223)	GPS ant to base GPS
3	USB or RS232 (F to F)	laptop to base GPS
4	RS232 (M to F)	base GPS com2 to radio
5	battery power to cigarette lighter socket	base GPS power
6	battery power to Phoenix conn	radio power
7	RS232 (M to M)	radio com null modem
8	RS232 (F to 7-pin Fischer)	survey GPS com

2.1 Base Station RTK GPS Setup

The following are the procedures for setting up the RTK GPS base station shown in figure 3:

1. Set up the base station GPS antenna on a level tripod directly over the surveyed point. Measure the height of the base station antenna phase center above the surveyed point. If using the Novatel choke ring antenna, its phase center is 50.8 mm (2 in) above the base of the antenna.
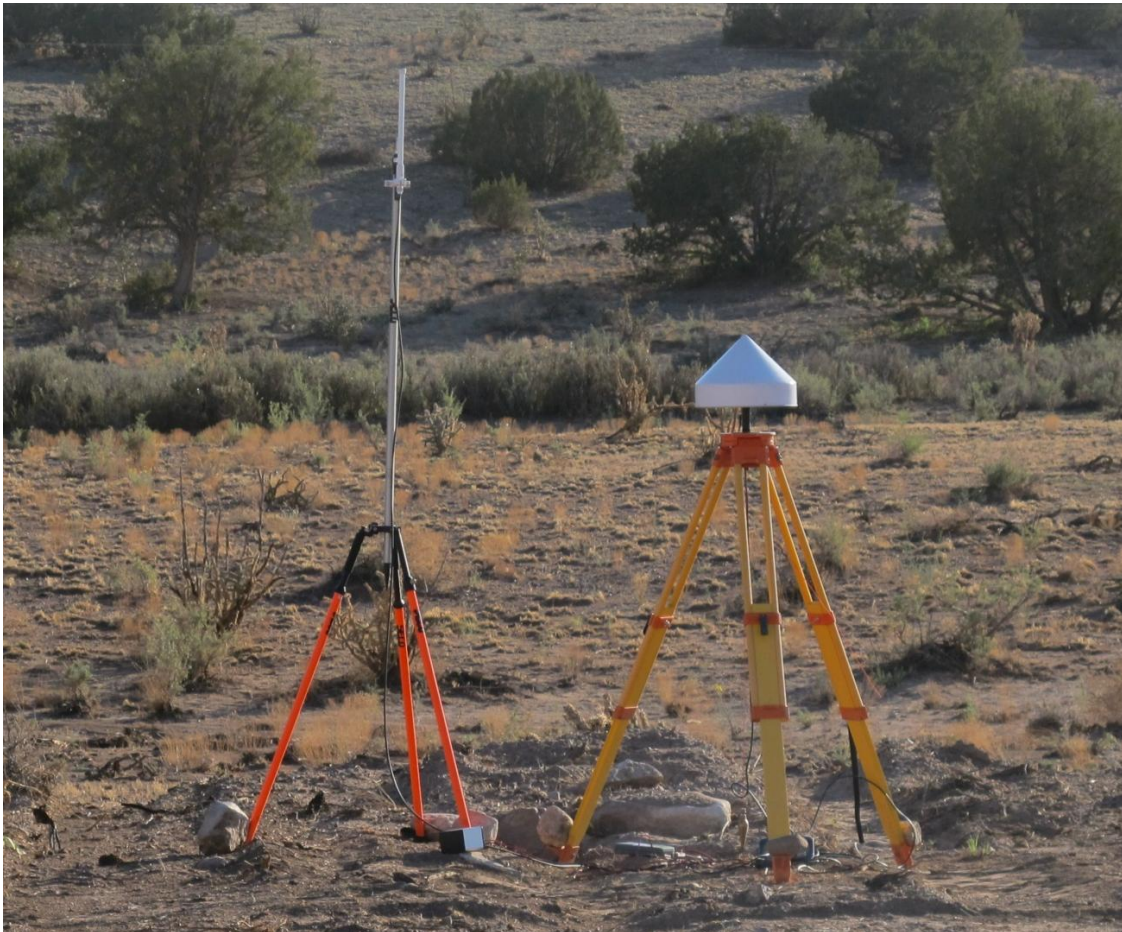

Figure 3. Photo of the base station setup.

2. Set up the antenna for the radio modem on a tripod that will have continuous line of sight to the survey unit.

3. Connect radio antenna to radio with type N to TNC coax (#1 in table 1).

4. Connect GPS antenna to GPS receiver with TNC to TNC coax (#2).

5. Connect the RS232 cable between the radio and the COM2 port of the GPS receiver (#4).

6. Connect the Y, 2-conductor power cable to the battery on one side and the radio and GPS receiver cigarette lighter socket on the other side (#5, #6). Push the power button on the front of the GPS receiver.

7. Connect a laptop to the GPS receiver with a universal serial bus (USB) or RS232 cable (#3).

8. Run the Control and Display Unit (CDU) program on the laptop, identify the correct COM port and connect to the GPS receiver. Figure 4 shows a typical display of the CDU window.
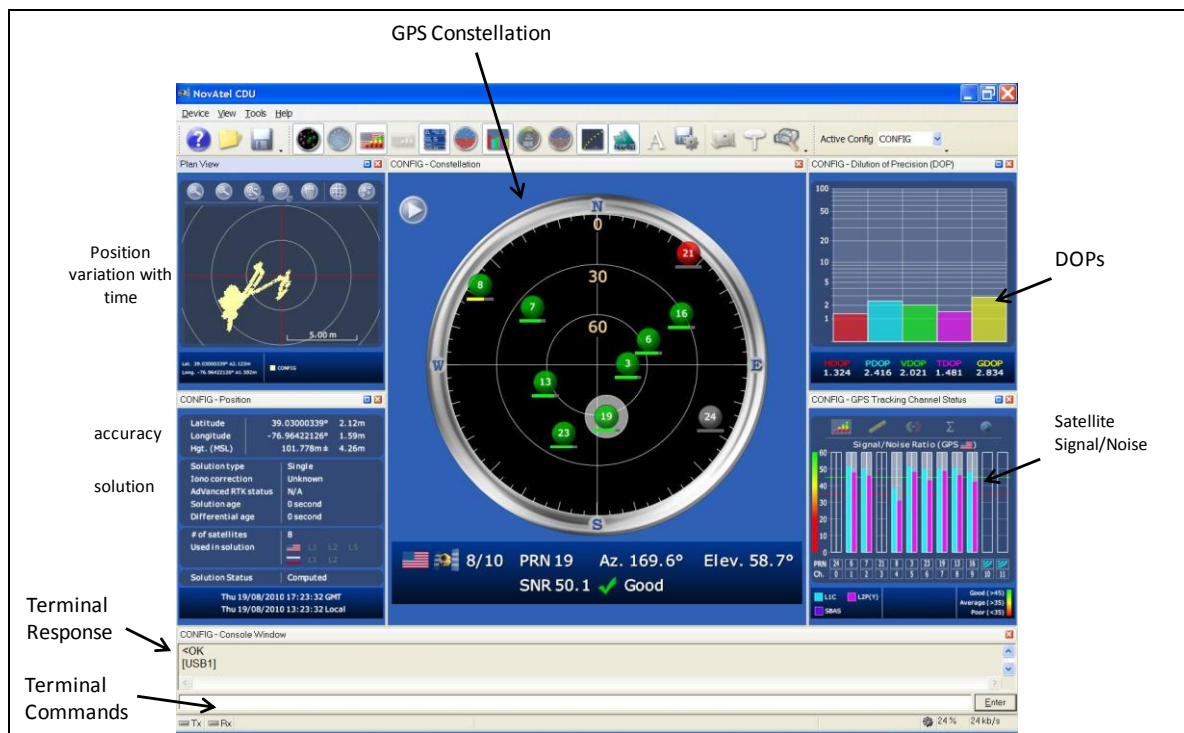

Figure 4. Novatel CDU software.

9. Commands can now either be entered into the terminal window or be activated by running a previously prepared batch file. The following commands are recommended for RTK operation.

Lines beginning with ';' are comments. Text in *italics* are explanations and not part of the commands. The FIX POSITION line will change coordinates depending on your location.


```
; Fixed base for ALC Bldg 601
UNLOGALL                              stops all previous logging
COM COM2 115200                       setup COM2 baud rate to 115K
INTERFACEMODE COM2 NONE RTCM OFF      setup COM2 port for corrections, no echo
LOG COM2 RTCM3 ONTIME 10              output base station parameters every 10 sec.
LOG COM2 RTCM22 ONTIME 10 1           output extended base parameters every 10
                                      sec., after 1 sec.
LOG COM2 RTCM1819 ONTIME 1            output carrier phase and pseudorange data
                                      every second
LOG COM2 RTCM1 ONTIME 5               output raw differential corrections every 5
                                      sec.
SBASCONTROL ENABLE WAAS               enable WAAS corrections from satellites
COMVOUT COM3 ON                       power up COM3
APPCONTROL BLUETOOTH 1                disable Bluetooth, enable ethernet
; Set undulation to 0 to use ellipsoidal height not msl
UNDULATION USER 0.0
; need to add height of antenna phase center
; ground is at 39.909m ellipsoidal height
; if base of ant is 1.12m above gnd and ph center is 5.1cm above base, then el ht
; of ph center is 41.080m
FIX POSITION 39.036155967 -76.953155694 41.080
```

2.2 Base Station Notes

The values entered into the FIX POSITION command should reflect the precise position of the *base station antenna phase center*. If using the Novatel choke ring antenna, its phase center is *50.8 mm* (2 in) above the base of the antenna. Once the FIX POSITION command is executed, the Radio Technical Commission for Maritime (RTCM) Services output will begin.

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3. RTK Survey Unit

The Survey Unit consists of a GPS receiver, the Ashtech ProMark 500; a 3.4-GHz radio modem, the FreeWave 3400-SMR; a display unit, the Magellan MobileMapper CX; a 12-V battery pack for the radio, and a survey pole to support the GPS receiver and Mobile Mapper. The interconnect diagram is shown in figure 5 followed by photos of the ProMark 500 and the MobileMapper CX (figures 6–8). Interconnecting cables are identified in table 1.
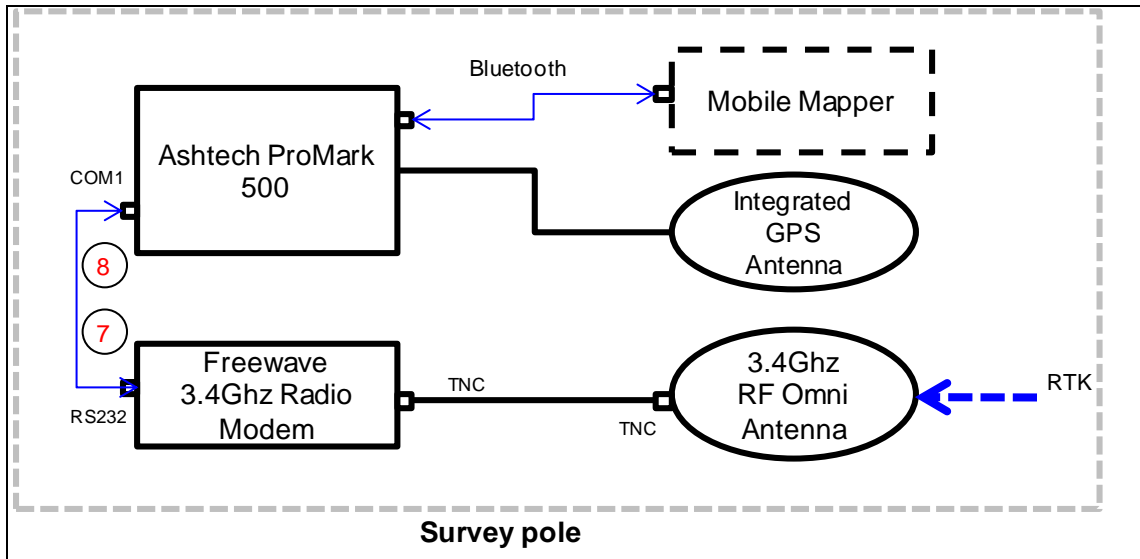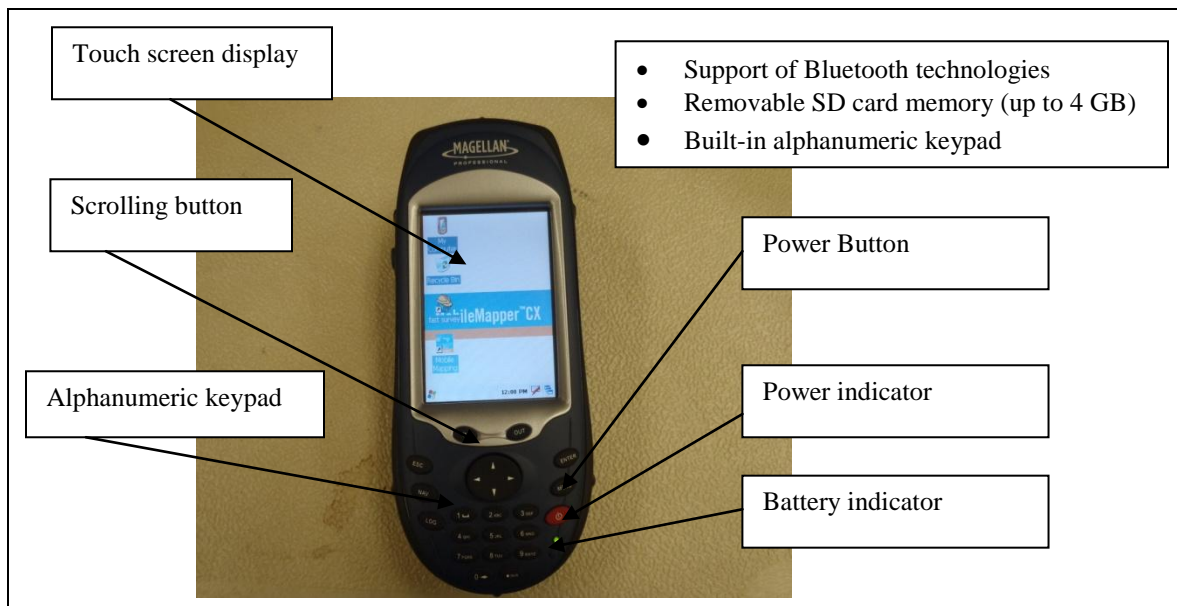
Figure 5. Survey Unit interconnect diagram.
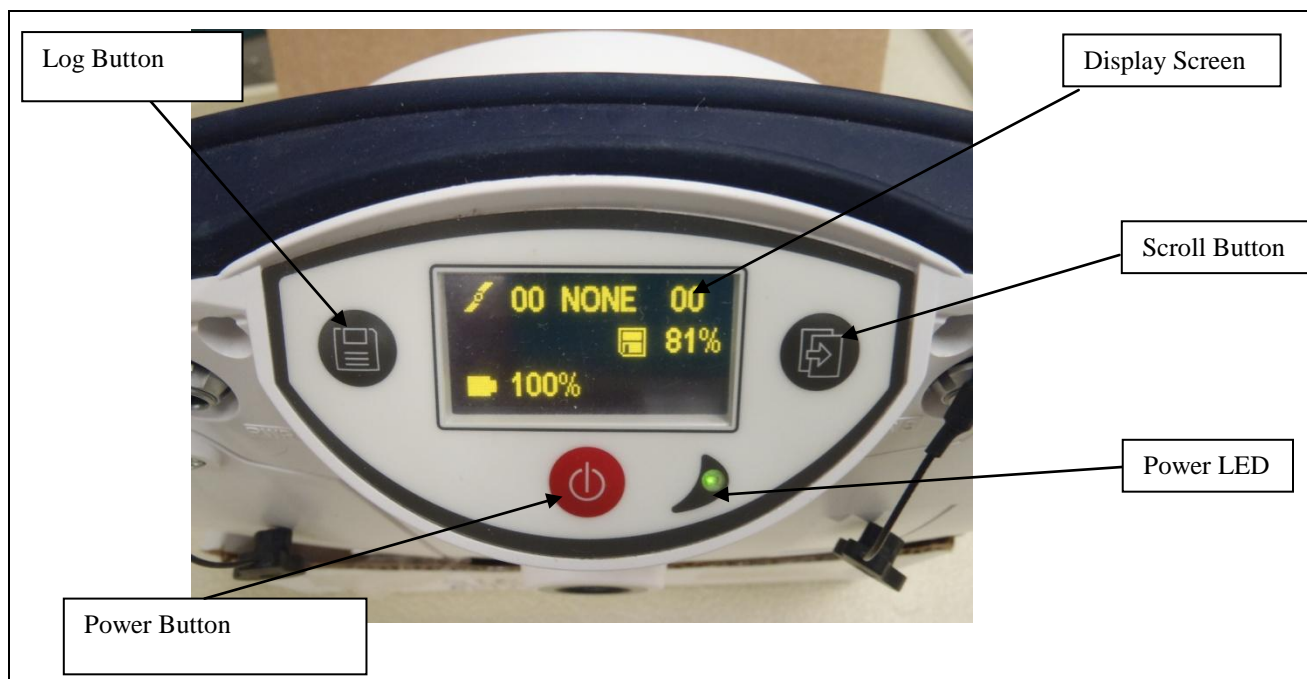

Figure 6. The MobileMapper CX.
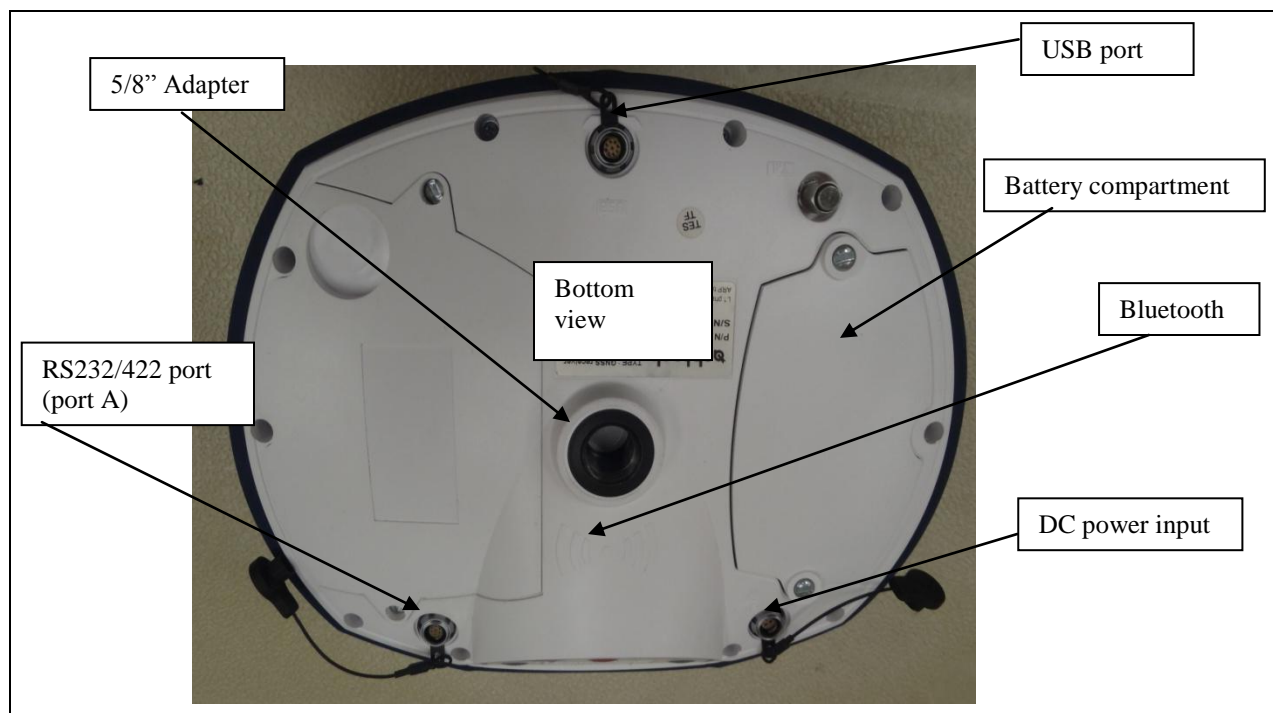
Figure 7. Front panel view of the ProMark 500.

Figure 8. Bottom view of the ProMark 500.

3.1   Survey Unit RTK GPS Setup

The following are the procedures for setting up the RTK GPS Survey Unit:

1. Connect the radio modem to the ProMark 500 with serial cable #7 and #8.

2. Connect the small omni antenna to the radio modem.

3. Connect the 2-conductor power cable to the 12-V battery pack on one end and the radio on the other end (#6).

4. Place the radio with antenna and battery pack in a backpack or handbag.

5. Using the mounting bracket, mount the MobileMapper CX on the survey pole at a comfortable height for operating and typing.

6. Turn on the ProMark 500 and the MobileMapper CX to make sure their internal batteries are fully charged.

3.2 FAST Survey

FAST Survey is data collection software designed by Ashtech to control and optimize Ashtech receivers such as the ProMark 500, which we use to conduct RTK surveying. We have installed it on the MobileMapper CX receiver that is used as a display and data storage unit. In the following sections, we show how to create a FAST Survey job, perform an RTK configuration to establish communication between the MobileMapper CX and the ProMark 500, and conduct a survey using FAST Survey.

3.3 How to Create a New FAST Survey Job

The procedures to create a FAST Survey job are given below:

1. Turn on the MobileMapper CX and set the clock properly.

2. Start **FAST Survey**.

3. Click on the **Continue Last Job** button to continue a previously started job; otherwise, click on the **Select New/Existing** job button to create a new job.

4. If creating a new FAST Survey job, click on the highlighted "crd" file name located at the bottom of the screen and type in the new "crd" file name using the virtual keyboard (This file is where FAST Survey will store the data that is collected during your survey). Then click on the check mark to accept it.

5. The Job settings window will come up to allow the user to configure how the job will be created. Under the Job settings window are the following menus: Format, New job, Options, Stake, and System. After going through these menus, click the check mark to accept the default settings or the new settings if changes were made in one of the menus.

6. When the **Connecting to instrument** window comes up, click on **connect to the last blue tooth device** to connect to the ProMark 500 or the **continue without connection** button to examine settings without connecting to the device.

3.4 How to Perform an RTK Configuration to Establish Communication Between the Mobile Mapper and ProMark 500

In order to perform an RTK configuration of the Survey Unit, first make sure the ProMark 500 is properly mounted atop the survey pole with the Mobile Mapper mounted below it. Power up both units. Run FAST Survey on the Mobile Mapper and open a new FAST Survey job. Then go through the following steps to do the configuration:

1. Click on the **Equip** tab and then select the **GPS Rover** tab to display the **Current, Comms, Receiver,** and **RTK** menu options.

2. Tap on the **Current** option and select the Manufacturer ("Ashtech") and Model ("ProMark 500") of the GPS receiver for the survey.

3. Select the **Comms** option and set Bluetooth connection by selecting "Bluetooth" in the Type field and "Ashtech BT" in the Device field**.** Tap on the configure tab to select the Bluetooth identifier that corresponds to the receiver **(ProMark 500)**.

4. Tap on the Bluetooth logo to connect the Mobile Mapper CX to the ProMark 500 via Bluetooth.

5. Select the **Receiver** tab and set the receiver parameters such as the antenna height, typically entered as vertical height above ground, and elevation mask, the angle of elevation above the horizon to mask out, typically 5° to 10°.

6. The **RTK** tab allows the user to set the data link on the ProMark 500 side. For the device field, select "cable or generic device" from the list of options. Also select the baud rate from the list in the "Baud" field. Port A is by default selected as the communication port. The parity and stop bits are also selected as none and 1, respectively.

7. Finally, tap the check mark to load the settings to the FAST Survey.

3.5 Check for a "Fixed" Position Solution Before Starting the Survey

Once the survey unit (ProMark 500) has been configured, it starts getting correction data from the base station. To obtain maximum position accuracy, it is important to verify that it has a "Fixed" position solution, where all startup position ambiguities are resolved. Perform this check by clicking on the **Monitor/Skyplot tab** under the **EQUIP** menu. The HRMS (RMS horizontal position error) and VRMS (RMS vertical position error) will rapidly decrease from a few meters to less than 20 mm and the position status will switch from "AUTO" to "FLOAT" and finally "FIXED", as in figure 9. The **Monitor/Skyplot** tab also allows the user to obtain information on local position, quality of data, and the horizontal and vertical root-mean-square (RMS) values.
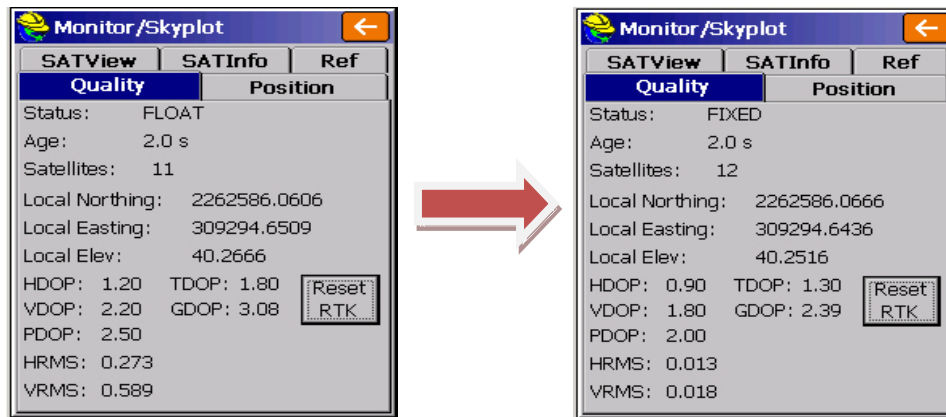
Figure 9. The display that allows you to review local position and quality of data.

Note the following definitions:

AUTO: No radio communication between base and rover.

FLOAT: Communication has been established, but ambiguities have not been resolved.

FIXED: Position has been resolved.

There are also other screens within the **Monitor/Skyplot** function that show the details of the base position (Ref tab), Satellite constellation (SATView), etc.

3.6   How to Conduct RTK Surveying Using Store Points Tool

Store Points is the principal data collection routine under FAST Survey. The Store Points screen (figure 10) shows the cursor moving on the screen in real time. As the user moves to the point of interest**,** the screen will pan automatically so that the base is always in view and points are plotted as readings are being taken. The following procedure is used to collect survey points using the Store Points tool.

1. Under the **Survey menu**, click on **Store Points** tab to open up the Store Points window and start collecting position information of a point.

2. Type in the point name and description of the point on (**Pt:**) and (**Desc:**) fields, respectively.

3. Before taking reading of a point, hold the survey stick level and steady and click on the "**S**" tab, which allows the user to take 30 readings by default and store the average. The default number of readings can be changed using the configure ("**C**") button.

4. The user can also tap the "**A**" button to read and store points, but it will still prompt for the number of readings to take (up to 999).

5. Finally, tapping on the check mark causes the "**Point Stored**" message to display briefly. The screen then shows the location, the name, and the description of the point (target).
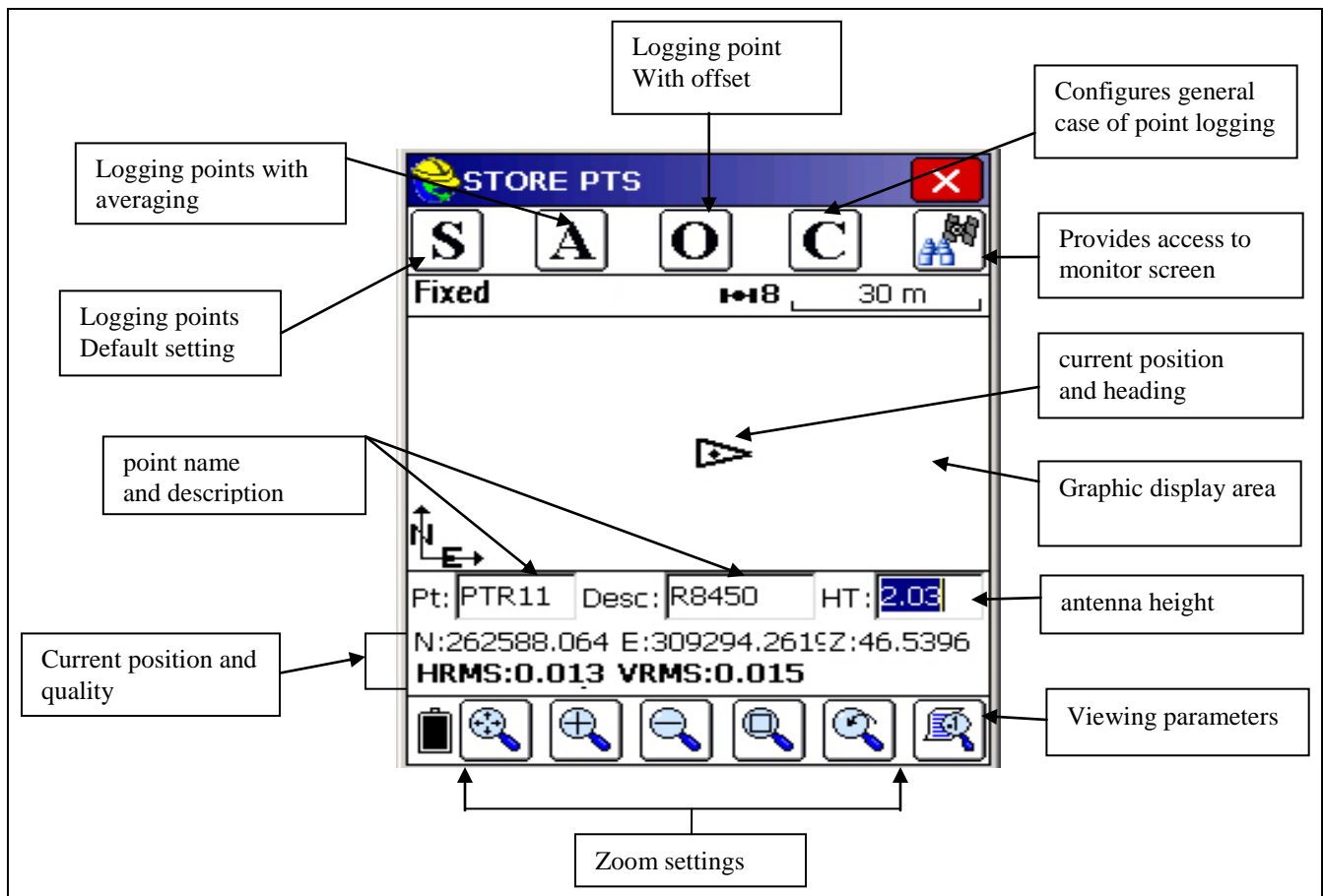
Figure 10. Store Points window.

3.7 Procedure to Export the Survey Points to a Text (ASCII) File Format

Once the survey is complete, the data can be exported to a text file for downloading to a PC or storage device. The following is the procedure to export the survey points to text file format:

1. Select the **Job** under the **FILE** menu and open the job to export by double clicking on the job name (.crd).

2. Then, from the file menu, click on the **Import/export** tab, which opens the **Import/Export** window with "**Import Ascii File"** and "**Export Ascii File"** options.

3. Click on "**Export Ascii file"** tab, which opens the Export Ascii window with a list of setting options. Select the desired settings and click the check mark to converts FAST Survey point data to an ASCII text file.

4. Then click the check mark to accept the settings and name the file.

5. Finally, click the check mark to save the file.

3.8 Procedure to Transfer Files/Folders from the Mobile Mapper to a PC using Microsoft Active Sync Software

The following are the procedures for transferring files/folders from the Mobile Mapper to a PC using Microsoft Active Sync software:

1. Connect the Mobile Mapper to a PC using a USB cable.

2. Microsoft Active Sync window will pop up on the PC displaying the "**connected"** message.

3. Click on the Explore device button to open the file explorer.

4. Go to the directory where the data are stored.

5. Then drag and drop or copy and paste the desired files from the Mobile Mapper to a folder on the PC.

3.9 Procedure to Transfer Files/Folders from the Mobile Mapper Directly to a Thumb Drive or a Hard Drive

The following are the procedures for transferring files/folders from the Mobile Mapper directly to a thumb drive or hard drive:

1. Click on My Computer on the Mobile Mapper.

2. Double click on MyDevice to list all files and folders on the Mobile Mapper.

3. Copy the desired file or folder to transfer to the thumb drive.

4. Double click on the Hard Disk (thumb drive) label to list all files and folders on it.

5. Create or open an existing folder and paste the copied file or folder.

4. Conclusion

We obtained centimeter accuracy of position data through the proper use of a real-time DGPS solution. A stationary (base station) GPS receiver was set up in the test area to collect data and transmit it over a radio link to the rover. The survey unit (rover) was mounted on a survey pole with a radio receiver to receive correction data from the base station. The radio link provides the DGPS solution to the rover in real time.

5. References

1. Ressler, M.; Nguyen, L.; Koenig, F.; Smith, G. Synchronous Impulse Reconstruction (SIRE) Radar Sensor for Autonomous Navigation. *Army Science Conference*, Nov 2006.

2. Koenig, F.; Wong, D. *Real-time Kinematics Global Positioning System (GPS) Operation and Setup Method for the Synchronous Impulse Reconstruction (SIRE) Radar*; ARL-TN-0393; U.S. Army Research Laboratory: Adelphi, MD, May 2010.

3. Koenig, F.; Wong, D. *Differential Global Positioning System (DGPS) Operation and Post-Processing Method for the Synchronous Impulse Reconstruction (SIRE) Radar*; ARL-TN-0281; U.S. Army Research Laboratory: Adelphi, MD, June 2007.